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REPORTS  
Annual

January 8, 1948

ANNUAL REPORT AND PROGRAM

TROPICAL FOREST EXPERIMENT STATION

CALENDAR YEAR 1947

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## ANNUAL REPORT AND PROGRAM

Calendar Year 1947

The program of the Tropical Forest Experiment Station, a branch of the Tropical Region of the Forest Service, continued to follow in 1947 the same general course as was laid out for the previous year.<sup>1/</sup> One staff member although absent on educational furlough much of the year continued to contribute research information and hence almost the full complement of events and progress on current projects characterized the year's activities.

### GENERAL FEATURES OF THE WORK PROGRAM

The program of studies generally was oriented to the needs of National and Insular Forest Administration in Puerto Rico, yet it was also guided to a substantial degree to be of help in the management of tropical forests elsewhere in the Caribbean Area.

### Project Emphasis

Silviculture and mensuration continued to receive major attention. Even in the beginnings of the practice of forestry some knowledge of silvical characteristics of trees and their growth rates are essential; hence efforts were made to start the long-time studies necessary to collect this information wherever forest sites and types are sufficiently extensive to warrant their study.

Regeneration research included the completion of the intensive surveys of all existing plantations in Puerto Rico and the analysis of results for publication early in 1948. A few studies of special problems, chiefly in the nursery, were continued.

A record of past dendrological studies is included in this report, but until funds are appropriated to the Station for continued research in this field, further active work on the ground must be postponed.

A summary of past wood utilization studies is also included later in this report. A new development of the past year supplies considerable encouragement for the future in this field, however, and the results will be of increasing help to silviculture as well as to the better utilization of tropical woods. The plan, proposed by the Director of the Forest Products Laboratory, provides for setting aside as large an allotment of forest products research funds as may be available each year (up to \$5,000 for the first year), for tests and studies of the important species of

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<sup>1/</sup> The history of the development of the research program of the Station since its establishment in 1939, the shifts in emphasis among the various projects from year to year, and the plan of research for the next few years were discussed in the Annual Report for 1946.

Puerto Rican woods. The first step will be to assemble and check all known and usable data on native woods. A preliminary list of the more important woods has been furnished the Laboratory and a bibliography of available information on all species has been started at the Station. Succeeding steps will comprise further tests to round out present data that may be incomplete for any of the more plentiful or valuable woods and tests of species of potential importance for which little or no property and behavior data are now available.

### Research and Forest Administration

One of the distinctive advantages of a combined office in Puerto Rico, in charge of both National and Insular Forest Administration and Research, is the possibility of direct service by the research organization to the technical problems of administration as those problems arise. Three examples of such assistance by research during the past year are in evidence.

### Forest Inventory and Plan

The inventory project, described more fully in the project status sheets in the Appendix of this report, has as its objective the collection and analysis of the data necessary to and their use in the preparation of a plan for the sustained yield management of the largest Division of the Caribbean National Forest. This project represents a departure from the usual concept of the dividing line between investigative and administrative functions. Elsewhere the basic data for a management plan may come from research, but the plan itself is usually an administrative task. The situation in Puerto Rico, however, appears to justify planning as a function of research, because the entire project is one of pioneering. Before the research work was begun the utility of the many species, growth rates, sites, types, timber volumes, silvicultural practices, and markets were only incompletely known. The synthesis of the data into a plan is a small part of the work; the adaptation for this region is the major task. The first plan will serve as a pattern for the gradual development, as more scientific information is available from research, for the ideal long-time plan of management of all of the resources of the Caribbean Forest, probably the most intensively used Forest in the entire National system. Likewise the plan will be of assistance to other countries in the American Tropics which have the planning still to do. When the plan is completed, the research organization will retire from the field of actual management planning and confine its efforts to the collection of additional and more intensive data for the improvement of the plan by Administration. An outgrowth of this project already apparent is acquainting the research staff with the shortcomings of existing information which in turn results in the desirable gradual reorientation of the research program toward the most important problems.

The Insular Forest Service was authorized by the Legislature of Puerto Rico two years ago to make an inventory of all the forest resources of the Island and to prepare a general plan for their future management. This inventory and planning project of Federal Forest Research contributed



to the planning for and the conduct of the field work by the Insular Service. And of the estimated 600,000 cuerdas (583,000 acres) of lands in Puerto Rico considered to be chiefly valuable for growing trees, including coffee plantations, about one-third has been covered by the reconnaissance to date.

#### Forest Nursery Costkeeping

A need has existed for a simple system of cost-keeping in the Insular forest nursery located on National Forest land and for the two new large nurseries now being established by the Insular Service which by law must supply all of the forest trees, shade trees, and ornamental plant material required by all Insular agencies in their own tree planting and landscaping work and by farmers and other landowners. This job was undertaken by Research during the past year in cooperation with the Insular staff, again because Research was in the better position to do it. Certain data previously collected primarily for their value in regard to biological aspects of stock production were segregated and where of direct real value were used as a beginning. Other technical data needed are being determined through research. The balance of the required information is being obtained by the Insular Service in its operation of the nurseries, but more cheaply through using the sampling techniques proposed by the research staff.

#### Past Plantation Analyses

The plantation records for the Caribbean National Forest had become more and more difficult to maintain satisfactorily and to interpret because of failures, replantings of various species during different years, and obliterated boundaries. Research undertook the job of straightening them out and fixing a new practical system for appraisal, classification, and graphic recordation. That job is completed. All past records were appraised. Many essentially similar plantations were combined. Records were simplified by confining those of the administrative organization to merely the data concerning future job loads (new planting, replanting, weeding, thinning, liberation). In doing so new technical information even beyond a "pilot plant" stage was obtained. Yet to be done by Research is the collection and interpretation of other types of information existent in these plantations through the establishment of representative sample plots to obtain data on growth, site adaptability, results of different treatments, mortality, etc.

The records and results of the many more thousands of acres of Insular plantations will now be brought on to the same scheme.

#### THE EXPERIMENTAL FORESTS

Three experimental forests, St. Just, Río Piedras and Cambalache, continued in use during 1947. The following information on these work centers is not included in the project status sheets which conclude this report.

### St. Just

The forest on the St. Just area (28 acres) is typical of the low hills with cutover land found in the agricultural areas near the coast. Data are being obtained on the adaptability and growth of numerous tree species, both native and exotic, on sites suitable for farm forestry. Perhaps the most important finding this year is the great improvement in growth and composition of the second growth brush areas which is obtainable by intensive harvest cuttings for the procurement of fuel and fence posts. Improvement cuttings made during the year in seven acres yielded 14 cords of fuelwood given free to 11 nearby families.

### Río Piedras

Studies in the Río Piedras woodlot (9 acres), located less than 1/2 mile from headquarters, has confirmed the findings in the St. Just forest and also of other natural stands that a fast response is obtained by the protection and harvesting of wood products in what were mere brush areas. Forest tree seedlings of many species grow well in the shady environment afforded by even a young, low stand. Release work is less expensive than when seedlings are planted in the open. Two sample plots, one in mixed hardwoods and the other in nearly pure pomarrosa, were measured. The average annual diameter growth of the dominant trees in the mixed type was 0.54 inches and for all trees 0.13 inches which represents retarded growth due to a large percentage of suppressed trees. The basal area of the forest is 85 sq. ft. per acre. The pomarrosa plot (coppice) had a basal area of 90 sq. ft. per acre. The gain in basal area for this plot during the last three years is 5 sq. ft. per year. A total of 1,200 fence posts were cut from the eight acres for the use of the Agricultural Experiment Station.

### Cambalache

The Cambalache Experimental Forest (616 acres) has continued to be important for planting and silvicultural research and as a provider of fuel for one of the most densely populated rural sections of Puerto Rico.

Research data and information gained in the management of this forest will be of great value in the handling of the larger blocks of second growth forest scheduled for ultimate transfer from the Land Authority of Puerto Rico to the Insular Forest Service. These blocks are located on the same formation of limestone hills and are practically identical with the Cambalache Experimental Forest.

The first improvement cutting of an area of about 8 acres of a low very dense second growth stand produced 32 cords of wood and 1,220 posts. A total of 38 timber sales was made, including 1,248 posts and 27.75 cords of fuelwood, with cash receipts of \$303.46. The sale of these wood products will cover about 70 per cent of the labor cost of the job. The reason the job did not pay its way was due to the very fine and crooked material removed in the first operation which was both expensive to handle and of low sales



value. The stand was greatly improved, however, and during the next cutting the sale of the wood products should contribute a much higher percentage of the labor cost because of the larger size and better quality of the products. In addition a total of 93 nearby families removed 3,517 bundles of dead fuelwood equivalent to 68 cords during the past year.

The return to and the increasing use of kerosene stoves, following their scarcity during the war, is a large factor in reducing the demand for wood fuel in the island. This is specially true in such overpopulated and deforested sections as Cambalache.

The Cambalache area was also used for other tests. One-hundred-fifty culms of Bambusa tulda were planted on Hill No. 17 with a very high survival to date. Two-hundred plants of yarey palm were also test planted but with fair survival. This palm is the leading source of fiber for hat making and is extensively used for miscellaneous articles. Mass propagation of this species will re-establish the extensive "Panama" hat industry of former days in Puerto Rico.

A graveyard test of 32 fence post species with a total of 256 posts was also started in the experimental area.

#### INTER-AMERICAN FORESTRY RELATIONS

The Director of the Station continued to serve as the Chairman of the Forestry Sub-Committee, Committee on Agriculture, Nutrition, Fisheries and Forestry, Agricultural Research Council, of the Caribbean Commission. He served jointly with the Senior Assistant Conservator, Forestry Department, Trinidad and Tobago, B.W.I., in the technical editing of the report and recommendations of the meeting of the Forestry Subcommittee, held in January 1945 at Port of Spain, Trinidad (see last year's Annual Report). This report has just been published by the Commission under the title of Forest Research Within the Caribbean Area<sup>2/</sup>.

New contacts were established and cooperation was begun with the Forest Department, Food and Agriculture Organization, United Nations, Washington, D.C., and with the Inter-American Institute of Agricultural Sciences, Turrialba, Costa Rica. The latter included the preparation, at the request of its Director, of a preliminary plan of research in tropical forestry and for placing the Institute's block of timberland under good management.

A third piece of mutually helpful cooperation undertaken during the year was closer contact and the direct exchange of technical information with some of the Agricultural Experiment Stations jointly operated by the Office of Foreign Agricultural Relations of the U. S. Department of

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<sup>2/</sup> Copy of this report can be obtained by addressing an inquiry to the General Secretariat, Caribbean Commission, Kent House, Port of Spain, Trinidad, B.W.I.

Agriculture and the country concerned, notably the Station at Tingo María, Perú.

#### INFORMATION AND EDUCATION

During the year 11 technical articles on the results of recent work at the Station were published; and the public was reached through three local press releases and one radio address. A round table discussion was organized and presented before a meeting of the Río Piedras Chapter of the Society of Agronomists and two talks were given on the interrelation of coffee plantations and timber forests at a symposium on coffee held by the Puerto Rican Chapter of the American Association of Agricultural Sciences.

Some 350 new photographs of forests and forestry work were taken for publicity purposes. The best of these are filed at Washington. Plans for the coming year include articles on timber sales, the parcelero system, the results of the plantation surveys, continuation of the Spanish-English glossary of forestry terminology, a study of climate in Puerto Rican forests, and press releases at opportune times.

#### STATION PERSONNEL

##### Staff Training

Frank H. Wadsworth, who spent most of the year in college resident work for a Ph.D. degree, made three trips which will be of value in improving the effectiveness of the work of the Station. Discussed with representatives of all branches of Research in the Washington Office were such subjects as forest management planning, recent forest influences research, wildlife management with special reference to the Puerto Rican parrot, volume table construction, and forest survey techniques. At the Southeastern Station he visited the Coweeta and Bent Creek Experimental forests. Both of these deal with forest types not greatly different in structure from those of upland Puerto Rico and the results of several of the management experiments and the findings to date on the effects of different types, intensities, and methods of timber exploitation upon water behavior will be quite applicable to Puerto Rico. Mr. Wadsworth also attended the first week of the second meeting on Forest Survey techniques at Eagle River, Wisconsin, September 29-October 3 and obtained helpful suggestions on methods for conducting both the forest inventory for management planning and the general Island-wide forest survey of the Insular Forest Service.

José Marrero of the Research staff, after 15 months in advance college training and his return to duty in the fall of 1946, completed his thesis for a Master's degree in Forestry on the results of past forest plantings in the Caribbean National Forest. Mr. Marrero is acting in charge of the research work during the absence of Mr. Wadsworth.

Zhura C. del Valle spent four months in Washington, D. C. where she took several courses relating to her work as laboratory helper, in the Graduate School of the U. S. Department of Agriculture.



### Research Staff

There were no separations from the research staff during the year. The personnel as of January 1, 1948 is as follows:

Arthur T. Upson*	Director, Tropical Region (also Director, Insular Forest Service)
Ana T. Vega de Jiménez*	Clerk-Stenographer
L. Verle Heljeson*	Administrative Assistant; Fiscal Agent
Angel L. Ferrer*	Clerk
Francisco L. Alfaro*	Clerk-Typist
Frank H. Wadsworth	Silviculturist
José Marrero	Forester
Luz Silva	Stenographer
Carmen Garoía-Piquera Ruiz	Translator
Raúl Ybarra Coronado	Forestry Aid (Research)
Zhura C. del Valle	Laboratory Helper
Antonio Cruz Soto	Skilled Laborer
Mauricio Osorio Rivera*	Unskilled Laborer

### Collaborators

Luis Enrique Gregory	Taxonomist, Puerto Rico
Luis F. Martorell	Entomologist, Puerto Rico
Leslie R. Holdridge	

\*Assigned to Tropical Region; time divided between Tropical Forest Experiment Station and Caribbean National Forest.

PUBLICATIONS AND PAPERS

García-Piquera, Carmen

A Spanish-English glossary of forestry terminology, II.  
Carib. For. 8:45-64.

A Spanish-English glossary of forestry terminology, III.  
Carib. For. 8:269-286.

Marrero, José

The proper depth and kind of covering for seeds of several tropical hardwoods. Carib. For. 8:213-236.

Efecto de la poda radicular de dos especies forestales.  
Carib. For. 8:241-244.

Contribución de la zona cafetalera a las necesidades forestales y a las fuentes fluviales de Puerto Rico.  
Revista del Café (in press)

Upson, Arthur

Problemas poblacionales y de migración de la zona cafetalera. Revista del Café (in press)

Wadsworth, Frank H.

Growth in the lower montane rain forest of Puerto Rico.  
Carib. For. 8:27-44.

The development of Swietenia mahagoni Jacq. on St. Croix.  
Carib. For. 8:161-164.

The third year in the Cambalache Experimental Forest.  
Carib. For. 8:203-212.

An approach to silviculture in Tropical America and its application in Puerto Rico. Carib. For. 8:245-268.

The influence of forest upon climate and water behavior.  
Carib. For. 8:289-299.

## PRESENT STATUS OF RESEARCH

The progress of the research of the Station is summarized in the series of Project Status Sheets attached to this report. This method of presentation was devised by the Branch of Research many years ago and has proven of great value for a quick reference of the purpose, findings to date, and planned work for each authorized research project of the Forest Service.

The purpose of each project is broadly stated and generally includes much more than the scope of studies to date would indicate. The limited funds and legal restrictions on research in foreign countries make it impossible to progress on the broad front desirable. The studies now under way are believed to deal with the most pressing phases of each project which can be done within these limitations. The results of most of them have some value as indicators of what might be expected elsewhere in the Caribbean Area.

The findings reported here are those considered of greatest significance. Some of them are of value not so much for themselves as for the new avenues of investigation they open up. If the accomplishments listed for the past year are compared with the plans set up in the previous annual report, some changes will be found. These reflect shifts in emphasis during the year as a result of unexpected new developments which affect the relative priority of proposed studies. Some investigations previously planned have had to be abandoned because of such developments. The available space is, therefore, devoted to the results of work actually performed rather than to explanations of these changes. For the more important completed work full information is published in the pages of *The Caribbean Forester*. Additional information on the results of the studies not yet published can be obtained by addressing the Director of the Tropical Region.

Tree species are referred in the sheets by scientific name. To assist the reader in identifying these species and to acquaint him with the reasons for their importance, a list of those mentioned, together with pertinent notes, are given below.

Avicennia nitida Jacq., black mangrove, mangle negro.- Wood used mostly for fuelwood and the bark for tanning.

Bambusa longispiculata Gamble ex Brandis, bamboo, bambú.- Similar to Bambusa tulda, grows over 50 feet with a diameter of 2 to 4 inches and useful for industrial purposes.

Bambusa tulda Roxb., bamboo, bambú.- Tall bamboo growing to about 60 feet and diameter of 2 to 5 inches. Has been the most successful industrial bamboo used in the Island.

Bambusa tuldoidea Munro, bamboo, bambú.- Promising industrial bamboo. Grows to about 40 feet in height and a diameter up to 3 inches. The number of canes produced per culm is relatively large.



Buchenavia capitata (Vahl) Eichl., granadillo, yellow sander.- An attractive medium size tree with a yellow colored wood which polishes well and is used for furniture and cabinet work.

Bucida buceras L., úcar.- Grows near the coast specially on dry situations where it is one of the dominant species. Wood is durable and useful for construction.

Calophyllum calaba Jacq., maría.- Has been regenerated successfully in poor sites. Its wood is used for general construction, ship building, furniture, and other purposes.

Calycophyllum candidissimum (Vahl) DC., degame, lemon wood.- A highly ornamental tree whose wood is adapted to special uses such as arrow bows and for tool handles, articles of turnery, etc.

Casuarina equisetifolia Forst., Australian pine, casuarina.- A rapid growing, pine like tree used mainly for fuel, windbreaks, and ornament.

Casuarina lepidophloia F.v.M., New Zealand pine.- A very ornamental species of casuarina especially suitable for windbreaks, because of its pyramidal habit of growth and dense foliage.

Cedrela odorata L., Spanish cedar, cedro.- The native species of cedar in Puerto Rico. Trial plantings are being made in different sites.

Cedrela mexicana Roem., Spanish cedar, cedro.- One of the best known species of Spanish cedar. Its regeneration is yet an unsolved silvicultural problem.

Cordia alliodora (R&P) Cham, Capá prieto, Spanish elm.- One of the most highly appreciated timbers in the Caribbean. It has also been one of the most successful species in plantations.

Cupressus benthami (Endl.) Carr., ciprés, cypress.- A Mexican and Central American species of cypress. Successful plantations have been established in tropical countries even at low elevations. Durable timber of excellent working properties.

Cyrilla racemiflora L., palo colorado.- Grows in nearly pure stands at high elevations. Used only for charcoal. Provides nesting places for the native parrot.

Dacryodes excelsa Vahl, tabonuco, candle tree.- Medium size to large tree occurring in Puerto Rico and some of the Lesser Antilles. Occurs in almost pure stands. Wood is used for carpentry, furniture, and general purposes.

Dendrocalamus strictus Nees, Indian bamboo, bambú.- A slow growing bamboo reaching a height of 60 feet and a diameter of 2 to 4 inches. Noted for its ability to withstand drought.

Didymopanax morototoni (Aubl.) Dene. & Pl., yagrumo macho.- Is a fast growing pioneer species producing a soft wood used for making matches.

Eucalyptus sp., eucalipto.- This is a large genus of wide distribution in subtropical and tropical climates. Is popular with landowners.

Eugenia jambos L., pomarrosa, rose apple.- An exotic aggressive species found widely naturalized. Is used for fuelwood, posts, and barrel hoops.

Euterpe globosa Gaertn., sierra palm, palma de sierra.- Little used. Occurs in dense stands in the mountain forests.

Fraxinus sp., fresno del Hawaii, cenizo.- Probably Fraxinus americana or white ash. Tried in small plantations in Puerto Rico but generally not very successful.

Guaiacum officinale L., guayacán, lignum vitae.- The well known lignum vitae of commerce. Is one of the species being favored in the dry forests being propagated by direct seeding.

Guarea trichilicoides L., guaraguao, musk wood.- A relative of the mahogany. Abundant in humid forests, producing an attractive mahogany-like wood used for carpentry and furniture.

Hyeronima clusioides (Tul.) Muell., cedro macho.- An attractive timber used for construction and furniture. Regenerates well naturally in the limestone areas.

Hymenaea courbaril L., algarrobo, West Indian locust.- One of the best timbers of the Caribbean. A tree of stately proportions producing wood highly resistant to the drywood termite used for furniture, carpentry, and construction of all kinds. Yields the copal gum of commerce.

Jambosa malaccensis (L.) DC., Malay apple.- Exotic fruit tree used also for windbreaks and for ornament.

Laguncularia racemosa (L.) Gaertn., white mangrove.- Wood used mostly for fuel and the bark for tanning.

Lucuma multiflora A. DC., jácana.- Has been direct seeded with good results in fair to good sites. Timber not well known.

Manilkara nitida (Sessé & Moc.) Dubard, Ausubo.- Attractive and well known construction timber. Is a commercial source of balata.

Montezuma speciosissima Sessé & Moc., maga colorada.- Wood is highly resistant to the drywood termite. Endemic to the Island, growing specially in the limestone areas.

Ocotea moschata (Pavon) Mez, nuez moscada.- Tree of very good form whose wood is locally highly appreciated for furniture.

Pinus caribaea Mor., slash pine.- Slash pine from southern United States and Cuba.

Pinus occidentalis Sw., Haitian pine.- Found in the Island of Hispaniola especially in the higher less accessible lands. Is a good construction timber.

Pinus rigida Mill. var. serotina (Michx.) Laud., pitch pine.- Well known hard pine of Eastern United States that maintains itself under exceedingly unfavorable conditions.

Prunus occidentalis Swartz, almendrón.- A well known tree of the West Indies producing a hard reddish timber suitable for construction.

Sciacassia siamea (Lam.) Brit., casia de Siam.- An introduced exotic from the East. Generally used for fuelwood, windbreaks, shade, and ornament. The wood is said to be hard, heavy, tough, durable, and suitable for inlays and turnery.

Sloanea berteriana Choisy, cacao motillo.- Grows in the mountain forests in Puerto Rico. Timber is heavy and of good mechanical properties although it is not much used locally.

Stahlia monosperma (Tul.) Urban, cóbana negra.- Slow growing tree of dry districts producing a dark durable wood used for inlays and for the most expensive type of furniture.

Swietenia mahagoni Jacq., West Indies mahogany.- The well known mahogany of the West Indies. Grows well in plantations in dry areas.

Swietenia macrophylla King, broadleaved or Honduras mahogany.- A tree of rapid growth adapted to good sites in humid localities.

Tectona grandis L., teak, teca.- The Burma teak of commerce. Has been successfully established in plantations in the West Indies.

Tetragastris balsamifera (Sw.) Kuntze, masa.- A medium size tree of the uplands in the West Indies. Its wood is used for interior construction, carpentry, furniture, and other wood uses.



## IMPROVEMENT OF TROPICAL FOREST STANDS

Field Division: Forest Management Research

Work Project: Silviculture

Line Project: Stand Improvement

Purpose: To adapt proven practices from elsewhere and to develop better methods for improving the growth rate and quality of existing natural or wild tropical forests.

Review of Past Work: Thinning of 20-year-old plantation of Calophyllum calaba at Maricao from 165 to 101 square feet of basal area per acre accelerated mean annual diameter growth of residual trees from 0.21 to 0.30 inch the first year after thinning and yielded poles and fuelwood sold for \$285.00 per acre. An improvement cutting liberating, thinning, and cleaning a young pole stand at Cambalache removed 430 trees 2 to 14 inches d.b.h., yielding 11 poles and 2.75 cords of fuelwood per acre, cost and returns \$16.67 and \$14.42 per acre respectively. A 0.075% aqueous solution of 2,4-D was found capable of killing vine growth but not young planted trees. Alemite spray gun, used with paint, was found satisfactory for marking trees for improvement cuttings, even in wet weather, and in dense young stands requires only half the time needed for blazing with ax or machete. At Luquillo even excessive opening of rain forest does not assure development of existing seedlings, since rapid-growing low-value trees, even from seed germinating after the cutting, may overtake and dominate desirable advance reproduction.

Accomplishments During Past Year: A second, larger-scale improvement cutting was made on 8 acres at Cambalache, removing 32 cords of fuelwood and 1,220 fence posts, and costing \$336 compared with value of products of \$242. Four plots were established in dense second growth in Luquillo mountains where individual tree growth will be measured for a few years before two plots are treated, thus providing before-and-after checks for concurrent subsequent growth comparisons. Weed-no-more 40 (an ester of 2,4-D) in 1 percent solution with diesel oil proved to be about as effective as aqueous solution for killing vines.

Plans for Next Year: Second remeasurement of Calophyllum thinning plots. Further tests of 2,4-D in vine control to determine techniques for large-scale treatment.

Date of Completion: Continuing.

Assignment: Wadsworth, Marrero

## SILVICS OF TROPICAL FORESTS

Field Division: Forest Management Research

Work Project: Silviculture

Line Project: Silvics - Environmental Factors

Purpose: To determine silvical characteristics and relationships of important tree species as a basis for silviculture in natural or wild tropical forests.

Review of Past Work: Permanent individual tree-growth records have been started on more than 12,000 trees of more than 100 species, growing in 28 stands of distinct composition, structure, and site. Diameter growth is being determined by tree species, site, position in the canopy, and apparent vigor classes. In relatively undisturbed mixed lower montane rain forest, dominant trees average 0.26 inch per year in diameter growth; codominants 90% as rapidly; intermediates, 60%; and suppressed, 27%. More than 80% of the trees are intermediate or suppressed. Among dominant trees those intolerant of shade grow only slightly more rapidly than tolerant trees, yet among the suppressed the disparity in favor of the tolerant trees is greater. Underplanted seedlings, however tolerant of shade, do not make rapid height growth unless average diameter of complete opening of canopy above them corresponds to at least 50° of arc, measured from tip of tree, or an equivalent amount of light received through a thin canopy. Current annual diameter growth in a dense 20-year-old plantation of Calophyllum calaba on poor laterite soil is 0.4 inch for dominant trees, 0.3 for codominants, and 0.2 inch for intermediates. For Bucida buceras in open stands on shallow limestone soil with 30" annual rainfall growth is 0.23" for dominants. For open-grown Eucalyptus robusta trees 10" d.b.h. on laterite soil with 100" rainfall growth is .013" during last year. On seacoast sandy soil Casuarina equisetifolia planted 8' x 8' can attain average diameter of 9.5" in ten years and 15" after 20 years. In a young mixed secondary stand growing near Río Piedras on north coast (basal area 60 sq. ft. per acre) dominants are growing an average of 0.82" in diameter per year; and average for all trees, 0.37". Swietenia macrophylla, a valuable exotic, is proving adapted to valleys and lower slopes in Luquillo mountains. Calophyllum calaba, native to lowlands, grows successfully on adverse sites in humid mountains. Similarly Montezuma speciosissima, native to coastal plain, grows well and with excellent form on slopes at 2,700 feet elevation at Toro Negro. Eucalyptus robusta and E. resinifera, both exotics, are well adapted to central mountains above 2,000 feet elevation, with rainfall of 80" - 110" annually.

Accomplishments During Past Year: Analyses of existing climatic records for the Luquillo mountains were made and showed that line between

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lower montane and montane rain forests here corresponds closely to 74°F annual isotherm, as determined by interpolation. Mountain tops (3,500 feet elevation) are about 10°F cooler than coast. Rainfall is three times as much as on adjacent coast, but extreme intensities are no higher. Winds of 60 m.p.h. are common on peaks. Analysis of 1937 cruise data shows average basal area in undisturbed montane rain forest in Luquillo mountains to be about 60 sq. ft. per acre. Densest stands are in west valleys (protected from trade winds), with considerable variation from valley to valley. Most prominent tree, Cyrilla racemiflora, is most commonly found on west slopes. Palm brake, on other hand, is found chiefly in more exposed eastern valleys. Its average basal area is about 40 sq. ft. per acre and is of uniform density throughout its range of occurrence in forest. These data were similarly analyzed to determine composition of seedlings and saplings of forest, for correlation with ground cover and stand density. It was discovered that two prominent trees of montane rain forest produce growth rings in their wood. An attempt is being made to determine whether these are annual through correlation with known dates of hurricanes and comparison with plot measurements. Euterpe globosa, a prominent but nearly worthless palm in the Luquillo mountains, may not be the rapid-growing aggressive species that was feared. A few trees, bent over by hurricane of 1928 grew only 5.2 feet in height in 18 years since they started to straighten up. A 30-acre permanent silvical plot with 5,061 trees was tagged and measured at Cambalache. Previously established silvical plots remeasured were El Verde mixed plots, casuarina in Sabana, Río Piedras mixed and pomarrosa plots, and El Verde experimental plantations. Small silvical growth plots were established in old plantations of Fraxinus sp. at Toro Negro, Cedrela mexicana at Luquillo, and Cordia alliodora at Carite. Self-recording rain gages were installed in Toro Negro Division of National Forest and in Guilarte Unit of Insular Forest.

Plans for Next Year: Analysis of plot data not yet completed. Remeasurement of all silvical plots in Luquillo mountains and analysis of individual tree growth by site, species, d.b.h., and crown class. Resurvey undisturbed natural regrowth on pasture at St. Just. Establish 1/4 acre silvical plots in Río Abajo plantations of Montezuma speciosissima, Tectona grandis, and Swietenia macrophylla.

Date of Completion: Continuing.

Assignment: Wadsworth, Marrero



## PLANTING STUDIES

Field Division: Forest Management Research

Work Project: Regeneration

Line Project: Planting

Purpose: To adapt proven practices from elsewhere and to develop improved methods of artificial reforestation of tropical forest species.

Review of Past Work: Detailed survey of all existing plantations in Caribbean National Forest (5,782 acres) showed that on proper sites valuable species which may be successfully established or introduced by planting are in the Luquillo Division, Cordia alliodora, Manilkara nitida, Lucuma multiflora, Ocotea moschata, Swietenia macrophylla, Tabebuia pallida, Calophyllum calaba (direct seeded), and Byrsonima spicata; and in Toro Negro Division, Eucalyptus robusta, E. resinifera, Cordia alliodora, Montezuma speciosissima, and Guarea trichilioides. Exploratory planting studies have been made with 131 native and exotic tree species. Tabebuia pallida, Guarea trichilioides, and Cordia alliodora can be established with wilding stock, which, if well-rooted, shows a higher survival than nursery stock. Bucida buceras, Dacryodes excelsa, Tetragastris balsamifera, Jambosa malaccensis, Eucalyptus citriodora, and E. maculata stock survives planting well only if transplanted with a ball of earth (tar-paper pots). Swietenia mahagoni and Stahlia monosperma survive well direct-seeded under partial shade. On moist sites (100" or more rainfall annually) Prunus occidentalis, Eucalyptus robusta, E. resinifera and E. alba can be planted successfully bare rooted. Culms of good bamboo being planted require prompt planting after lifting but with care high survival can be obtained on moist sites. Nursery stock of Swietenia macrophylla and Montezuma speciosissima can be stored in wet moss as long as eight days between lifting and planting without reduction in field survival.

Accomplishments During Past Year: Experimental plantings were made on various sites with newly introduced Eucalyptus stricta, E. coriacea, E. populifolia, E. rostrata, E. affinis, E. marginata, E. stuartiana, E. punctata, E. paniculata, E. globulus, and some hybrids. More extensive planting with Bambusa tulda, B. tuldoidea, B. longispiculata and Dendrocalamus strictus was made in high Luquillo lands otherwise of little value and early indications promise high survival. Plantings of cuttings of Bambusa tulda and B. tuldoidea was made on a very wet site nearby and early indications are also promising. Direct seeding of Swietenia macrophylla on dry site gave low survival, apparently chiefly due to abnormal drought. On better sites this may prove as successful as with S. mahagoni. Experimental planting of Bambusa tulda was made on rocky limestone hills at Cambalache and so far results are very promising.

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Plans for Next Year: Finish survey of and report on plantations of Insular Forests. Test hybrid pines, Pinus rigida var. serotina on swampy uplands. Experimental plantings of P. caribaea, P. occidentalis and Cupressus benthami will be made particularly in the uplands. Commence survey of private plantations to determine growth and adaptability of different species.

Date of Completion: Continuing

Assignment: Marrero, Wadsworth

## NURSERY STUDIES

Field Division: Forest Management Research

Work Project: Regeneration

Line Project: Nursery Studies

Purpose: To adapt proven practices from elsewhere and to develop improved methods for production of quality planting stock of tropical forest trees.

Review of Past Work: Exploratory studies of 102 native and exotic trees show that almost all species need partial shade during period of germination and first month of growth. Thereafter full sunlight produces more vigorous stock. Stock growth data have been summarized from an analysis of 3,159 past nursery sowings of 48 tree species. Optimum bed spacing for Eucalyptus spp. is 6" x 6"; for Casuarina spp. 1" x 6"; and for most other species tested, 3" x 6". Seeds of Manilkara bidentata should be sown in moist leaves, as they are not sufficiently strong to push up through the soil. An aqueous solution of 0.075% 2,4-D kills herbaceous weeds (not grasses) in nursery beds with less damage to Eucalyptus resinifera, but even 0.0375% was fatal to Casuarina equisetifolia. Root system of Casuarina equisetifolia is materially improved by transplanting, which should be done when seedlings are 8 to 10 inches tall. Discontinuation of watering of Sciacassia siamea stock one month prior to lifting caused marked hardening of stock and higher field survival. Crotalaria striata is satisfactory nursery cover crop which provides good cover and abundance of organic matter in short time.

Accomplishments During Past Year: Application of lime and filter-press cake at the rate of 2 tons and 35 tons per acre respectively corrected, at least temporarily, soil difficulties at La Catalina nursery. Control of damping off in seedlings of Casuarina was effective with Spergon and Bordeaux mixture. Other chemicals, formalin, potassium permanganate and Zerlate were unsuccessful. Paris green mixed with wheat flour is still the most effective poison for the Puerto Rican mole cricket even when compared with D.D.T. Lead arsenate and lime mixture was effective in the control of the common cricket. Optimum size for transplanting Eucalyptus resinifera seedlings to beds was found to be between 2 and 4 inches. Tephrosia candida was not satisfactory as a cover crop because of slow growth. Crotalaria striata is considered the most satisfactory cover crop at this nursery.

Plans for Next Year: Continue experiments to improve shade control in nursery, tests of herbicides, and cover crops. Develop faster methods of transplanting seedlings to beds i.e. satisfactory transplant board or other device. Publication of results of propagation of Casuarina equisetifolia.

Date of Completion: Continuing

Assignment: Marrero



## SEED STUDIES

Field Division: Forest Management Research

Work Project: Regeneration

Line Project: Seed Studies

Purpose: To adapt proven practices from elsewhere and to develop improved methods of collection, extraction, storage, and testing of seed of the important tropical tree species.

Review of Past Work: Studies of germination and storage have been conducted with 169 native and exotic tree species. From nursery records of 11,584 sowings, including 294 tree species, data on rapidity of germination were summarized. Longevity of seeds of Swietenia macrophylla and Cedrela mexicana can be increased from three to nine months by storage at 40°F. Seed longevity of Cordia alliodora can be increased from four weeks to three months by desiccating to 25% of fresh moisture content and sealed storage at 40°F. Seed longevity of Montezuma speciosissima increases from two weeks to two months when dried to 62% of natural moisture content and stored at 40°F. Seed of Manilkara bidentata and Lucuma multiflora remains viable only one month at room temperature. Seeds of Guaiacum officinale are not mature until they turn orange. Cold storage is detrimental to retention of their viability. Low initial viability of seed of Bucida buceras (2%) is due to incomplete development of seed, and to insect attack. Concentrated sulfuric acid scarification of seed of Sciacassia siamea for 10 minutes shortens germination period from 60 to 10 days.

Accomplishments During Past Year: Seeds of 10 new species were weighed and tested, including Calycophyllum candidissimum and other species received from Soledad Gardens, Cuba. Heavy seed production was obtained from trees of Casuarina lepidophloia in Cambalache. There are few records of seed production by this species. About 500 potted seedlings were obtained from first seed lot.

Plans for Next Year: Study relationships between seed quality and parent tree in Bucida buceras and Hyeronima clusioides. Routine germination tests and weighing of available seeds of promising species not already tested. Test use of wetting agents in accelerating germination of hard seeds.

Date of Completion: Continuing

Assignment: Marrero

## TREE STUDIES

Field Division: Forest Management Research

Work Project: Mensuration

Line Project: Tree Studies

Purpose: To adapt proven practices from elsewhere and to develop improved methods for measurement, both before and after cutting, of the utilizable volume of trees of tropical species.

Review of Past Work: Several thousand trees measured in Luquillo mountains showed little variation by species from general average diameter-height relationship. Board-foot converting factors were developed for stakes, posts, poles, crossties, and oxyokes. Form-factor board-foot volume tables were prepared for Puerto Rican hardwoods by J. W. Girard.

Accomplishments During Past Year: With discovery that ocular estimates of tree volumes may be in error as much as 60% for a group as large as 200 trees, complete tree measurement of trunk and branches was begun for foundation of a volume table based on diameter and total height. Two-hundred-eighty-three trees have been measured in both lower montane and montane rain forest. Preliminary inspection points to possibility of making single table for both types and all species with sufficient accuracy for management planning purposes. Measurements have shown that, with few exceptions, bark thickness is similar for all species. Analysis of 1937 cruise of Luquillo forest, including some 39,000 trees, shows that only 15% of its species reach 12" d.b.h. Less than 7% reach 20". Survey of 22,000 trees of most important species showed that only 74 of these contained two 16' logs, and nearly all of these were Dacryodes excelsa.

Plans for Next Year: Continuation of tree measurements until adequate for a reliable volume table, and prepare table. Develop charcoal-cubic foot conversion factors.

Date of Completion: Continuing

Assignment: Wadsworth

## STAND STUDIES

Field Division: Forest Management Research

Work Project: Mensuration

Line Project: Stand Studies

Purpose: To determine the growth, mortality, and yield of important associations in tropical forests.

Review of Past Work: Young mangrove forest thinned to basal area of 38 sq. ft. per acre had grown to 97 sq. ft. seven years later. Young secondary forest near Río Piedras on north coast grew from 60 to 76 sq. ft. of basal area per acre in three years. Eight-year-old mangrove forest, cut to 3-inch diameter limit yielded 3,452 fence posts of 2" to 3" top diameter and 10 cords of fuelwood per acre. Ten-year-old plantation of Casuarina equisetifolia on seacoast produced 31.2 cords of wood per acre. Eight-year-old coppice stands of Eugenia jambos, when clear cut, yield 20 to 25 cords of wood per acre. Those yields per acre are marketable at from \$50 to \$90 on stump. Fourteen permanent growth plots, covering 43 acres, containing over 12,000 tagged trees, and established primarily for silvical study, will also provide information as to growth and mortality on area basis.

Accomplishments During Past Year: A 200-tree sample plot was established in older successful artificial stand of cedar on Caribbean Forest. Study of this plot should throw light on difficult problem of regenerating Spanish cedar artificially. Trees had an average d.b.h. of 3.5 inches 11.5 years after planting, and varied between 1" and 9" in diameter. A 10-year old unthinned Casuarina sample plot remeasured had average d.b.h. of 5.5 inches and contained 86 sq. ft. of basal area per acre.

Plans for Next Year: Analyze mangrove plot data. Tally mortality on El Verde plots in lower montane rain forest, for first data of this nature. Remeasure Humacao Casuarina plantation plots and analyze for stand growth. Analyze such data from recent silvical plot remeasurements as indicates characteristics of entire stands.

Date of Completion: Continuing

Assignment: Wadsworth



## INVENTORY, YIELD AND REQUIREMENTS

Field Division: Forest Survey

Work Project: Survey of Forest Resources, Present and Future Requirements.

Line Project: Inventory, Yield, Requirements

Purpose: To collect and interpret inventory, yield, and requirements data as a basis for a plan of sustained yield management of Luquillo Division of Caribbean National Forest in order to provide a pattern for such work on Insular and other tropical forests.

Review of Past Work: Large scale base and contour maps were drafted from Geological Survey quadrangles. Type lines, open areas, and probable limit of true forest land (decided largely by slope) were determined from aerial photographs and checked from air at low altitude. Working circles boundaries were established. Timber marking rules were drawn up, and tentative cutting budget set up, based on all existing data. Provisional minimum stumpage rates were established. In permanent growth plots referred to under "silvics" trees needing cutting were indicated on tally, providing basis for calculation of average stand removed and left.

Accomplishments During Past Year: Proposed land use pattern for Luquillo Division was revised in light of studies during year. Of entire Division, 10,542 acres are to be devoted primarily to timber production, 3,210 as last refuge for rare Puerto Rican parrot, 2,106 acres to preserve in its natural state best remaining stand of tropical rain forest in National Forest system, 2,426 acres of high ridges primarily for watershed protection, and 1,500 acres for recreation. Tentative cutting budget modified for every working circle affected by this new plan. Amount and composition of reproduction was determined from field survey data by working circles. Further progress made in bringing together all existing information on woods native to Luquillo area. Preliminary study of wind power possibilities made in cooperation with Weather Bureau which showed that in Luquillo mountains wind is sufficient and possibly sufficiently uniform for turbines.

Plans for Next Year: Complete appraisal of present and potential value of woods. Inventory forest of Luquillo mountains. Locate compartments. Modify marking policy and stumpage rates on basis of new findings. Synthesize all data into a plan for management for Luquillo Division.

Date of Completion: Early 1949

Assignment: Wadsworth

## INTER-AMERICAN COOPERATION

Field Division: Forest Management Research

Work Project: General

Line Project: Inter-American Cooperation

Purpose: To advance forestry in the Latin-American countries through assistance and cooperation in common regional problems.

Review of Past Work: The Caribbean Forester, an 80-page, trilingual, quarterly technical journal, has been published and distributed free of charge throughout the Central and South Americas since 1939 to a mailing list of about 600. Surveys of forest resources important during war were conducted in Costa Rica, Ecuador, and Chile. Active participation in work in forestry of Caribbean Research Council of Caribbean Commission, including attendance at meeting of Sub-committee, of which Director is Chairman, at Port-of-Spain in 1946 which appraised results of tropical forest research to date and proposed a program for future joint research through a proposed forest research center. One-hundred forestry terms with definitions in Spanish and English were published in The Caribbean Forester, as first part of complete glossary.

Accomplishments During Past Year: Four issues of The Caribbean Forester published, with articles concerning nine different countries and including nine articles by staff members. Two-hundred more glossary terms published. Another hundred ready for publication. Published report of Forestry Sub-committee in English edited by Sr. Assistant Conservator of Trinidad and Director of Tropical Region was released by Commission. Contact established with Forest Department of FAO. Preliminary plan for forest research and for management of forest properties furnished Inter-American Institute of Agricultural Sciences at request of its Director. About 25 requests for complete information on variety of forestry subjects from 16 different countries were answered by Research Staff.

Plans for Next Year: Take active part in placing forestry problems before proposed Inter-American Conference of Agriculture at Montevideo. Continue publication of The Caribbean Forester, including latest and most important findings of research at Station. Publish further installments of glossary terms. Translate Forestry Subcommittee report into Spanish for publication by Caribbean Commission and continue to participate in its forestry program.

Date of Completion: Glossary indefinite; balance of project continuing.

Assignment: Upson, García-Piquera, Wadsworth, Marrero

## DENDROLOGY

Field Division: Forest Management Research

Work Project: Silviculture

Line Project: Silvics-Tree Distribution, Dendrological Studies

Purpose: To identify and to facilitate identification of trees in tropical forests; to standardize common and taxonomic tree nomenclature; and to determine natural distribution of forest trees and associations of region.

Review of Past Work: Herbarium of about 2,000 specimens has been accumulated. Ink drawings of specimens of 325 trees have been prepared and 100 of these were published with descriptions in English and Spanish. Approximate original location of seven primary forest types of Puerto Rico has been determined. Natural areas have been established in Cam-balache experimental forest, Guánica and Maricao Insular forests and in Luquillo and Toro Negro Divisions of Caribbean Forest. Relatively undisturbed lower montane rain forest has been found to contain 40 to 50 species per acre. The dominant species, Dacryodes excelsa makes up 34% of basal area. No other species makes up more than 6%.

Accomplishments During the Past Year: Six plant specimens from Eucalyptus seed trees were sent to dendrologist in Washington for species identification.

Plans for Next Year: Compile sample plot data indicative of composition of associations, incidental to its summary for other purposes. Additional specimens of Eucalyptus to be sent for species identification.

Date of Completion: Indefinite

Assignment: None



## UTILIZATION OF PUERTO RICAN WOODS

Field Division: Forest Products

Work Project: Forest Utilization

Line Project: Forest Utilization

Purpose: To determine present and potential local requirements, superficial properties, and uses of Puerto Rican woods.

Review of Past Work: Untreated Sloanea berteriana heartwood was found resistant to teredos 18 months in San Juan harbor. Fence posts of more common species normally last less than 2 years in service in more humid sections of Puerto Rico. Six-hour hot and cold bath carbolineum treatment of Casuarina equisetifolia caused lateral penetration of 3/4 to 2 inches. Hot and cold bath treatment of 3-inch posts of Didymopanax morototoni with carbolineum gave complete penetration after 2 hours of boiling. Preliminary study and report of wood utilization in Puerto Rico made by Teesdale and Girard for Puerto Rico Development Co.. Approximate oven-dry specific gravities determined for 106 native and 3 exotic woods, with average found to be 0.70. Approximate green moisture content of sapwood of 28 native woods determined, and based on oven-dry weight, found to vary from 44 to 372 percent. Testing of 203 seasoned samples of 81 local woods showed equilibrium moisture content at Río Piedras to be 14.6 percent. Two mangrove species, Avicennia nitida and Laguncularia racemosa, contained 19.0 and 18.3 percent respectively suggesting possibility that presence of salts in these woods may influence moisture content. Samples of more than 500 woods were received from Ecuador and Dutch Guiana. Logs of Dacryodes excelsa, Sloanea berteriana and Pinus occidentalis were sent to Duke University for testing.

Accomplishments During Past Year: Small scale test of 32 common species of fence posts was set up by Forest Officer at Cambalache. Casuarina posts treated full-length with carbolineum were serviceable after 3 years of exposure in humid location. Posts where only base had been treated were beginning to break down after 2-1/2 years of exposure in mangrove swamp, but mainly because of bad spiral cracking starting from top. Logs of Manilkara bidentata, Hymenaea courbaril, Buchenavia capitata, and Tetragastris balsamifera were sent to Yale University for testing. In cooperation with P. R. Development Co. 129, 1-1/2" squares 4 feet long of six different local species were sent to an Eastern Laboratory for testing for manufacture into spools for a Thread Company interested in establishing factory in Puerto Rico. Cooperating with Dr. G. N. Wolcott in his termite studies few specimens were sent to Yale University for identification. Forest Products Laboratory proposes to allot about \$5,000 to testing of important local species.

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Plans for Next Year: Routine examination of preservative tests in progress. Possibly shipment of more specimens to Yale, also to Forest Products Laboratory. Prepare bibliography of available reliable data from all sources on properties of P. R. woods.

Date of Completion: Indefinite

Assignment: García-Piquera (bibliography)